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EROSIONAL ORIGIN OF THE GREAT BASIN RANGES

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It is not at all probable that the origin of the mountain ranges of the Great Basin of western America can find adequate and satisfactory explanation by a single simple hypothesis. Nor can it be advantageously postulated that the genesis of the mountains is the same in the various parts of that vaster desert region of which the Great Basin is only a minor portion. In general all recent observations go to show that these mountains as they exist today must be regarded as the outcome of the action of several sorts of geologic forces, operating sometimes severally and sometimes in conjunction, at diverse times and with different degrees of intensity.

The relative ascendency of the several geologic processes in shaping the larger relief features of the desert region has remained until recently an indeterminate quantity. It is this aspect of the subject that has been all but entirely overlooked. This neglect has led to very divergent opinions, as is shown by a full dozen of distinct hypotheses advanced to explain the origin of the Basin ranges.

In the consideration of the origin of the American desert mountains, it is usually assumed that they are strictly structural features. That they may have been fashioned, partly at least, by other means is a suggestion which is only beginning to attract the attention which it merits. Present indications are that erosion—eolian erosion—must be reckoned with as one of the potent factors in desert sculpturing.

Many descriptions of the Great Basin ranges have been published. Notwithstanding this fact there has not yet appeared, as Davis[1] well says, "any detailed statement of the theory by which they are explained; the essential consequences of the theory have not been explicitly formulated; the criteria by which a fault-block mountain may be recognized in early or later stages of dissection have not been defined."

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[1] *Bull. Mus. Comp. Zoöl.*, XLII, p. 112, 1903.

Spurr[1] appears to be the first to bring into serious question the early explanation of Gilbert's, afterward adopted by King, Powell, Russell, and others,[2] regarding the simple fault-block origin of the Basin ranges. This author considers stream-corrasion as the most important or only sculpturing agency, but he expresses the opinion that erosion and upheaval have gone on together, more or less uninterruptedly ever since Jurassic times, the mountains being eroded from a folded substructure in the same way as in the case of the Appalachians, when the precipitation was much greater than at present, while "subsequently the climate became arid and the water-supply was not sufficient to remove the detritus from the valleys, which filled up." This view, however, as will be seen later, does not appear, according to Davis,[3] to be sufficiently supported.

The idea of the Basin ranges presented by Davis[4] recently is that they are "dissected fault-block mountains." The descriptions, and illustrations which accompany them, indicate clearly that the mountains are regarded as blocks first upheaved and tilted and then subjected to rapid corrasion by the mountain torrents, the intermont areas being deeply filled by the rock-waste of the contiguous highlands. This is practically Gilbert's hypothesis theoretically considered in its essential consequences, accompanied by the definition of some of the criteria by which the stages of dissection of a fault-block mountain may be recognized.

The Great Basin taken alone presents many difficulties to a clear interpretation of some of its most characteristic features. Farther south in the desert region, at the northern end of the Mexican tableland, there are displayed certain phenomena which seem to offer critical evidences bearing upon the question in hand. A few years ago I incidentally referred[5] to the probable significance of some of these features and to the physiographic evolution of that part of the country, regarding the region as a peneplain that had been uplifted in mid-Tertiary times, broken into high blocks, and then subjected to vigorous erosion, the effects of the latter being fully as important as the faulting in producing the present relief expression. Being fresh from the humid regions all denuding agents spelled water-action.

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[1] *Bull. Geol. Soc. America*, XII, p. 217, 1901.

[2] *Geog. and Geol. Expl. and Surv.* W. 100 Merid., Prog. Rept., p. 48, 1874.

[3] *Science*, N. S., XIV, p. 457, 1901.

[4] *Bull. Mus. Comp. Zoöl.*, XLII, p. 131, 1903.

[5] *American Geologist*, XXXIII, p. 22, 1904.

All of the above allusions to the erosional agencies in the desert ranges of the West have referred solely to the work of water. Of the possibility of the existence of any other effective denuding power there has been small hint. Only very recently have other erosive influences been suggested to account for some of the most conspicuous of the desert features. It now seems probable that wind-scour must be regarded as the chief erosive power in the dry regions.

In the Great Basin area the salient aspects of the country are quite different from the larger relief features of other parts of the western desert region. There is some of the faulting that is more recent and more profound than elsewhere. Late orogenic movements are perhaps more extensive. Evidences of much greater precipitation than now at no distant geologic date are manifest. No noteworthy streams traverse the district to disguise the effects of typical desert-leveling. Little is yet known in regard to the probable nature of the surface relief prior to the commencement of the present arid period. The general conditions are such as to present little critical evidence in support of any hypothesis yet proposed concerning the genesis of the desert ranges.

In other portions of the desert region far to the south and southeast of the Great Basin, in Arizona, New Mexico, and Old Mexico, there are many features suggestive of structures and conditions which formerly prevailed but of which there is small hint to be derived in the more northern area. The most noteworthy of these characteristics are the mesas, or plateau-plains, many of which now stand high above the present level of the intermont plains, or general plains-surface of the region. These mesas manifestly represent, as recently shown,[1] former positions of the general plains-surface. Their greater resistance to erosional influences and the general lowering of the region is due mainly to the protection afforded by extensive lava-flows which are now the capping-rock of the remnantal levels. The surfaces on which the lavas rest are true beveled rock-floors, just as in the cases of the present plains.

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[1] *Bull. Geol. Soc. America*, XIX, p. 63, 1908.

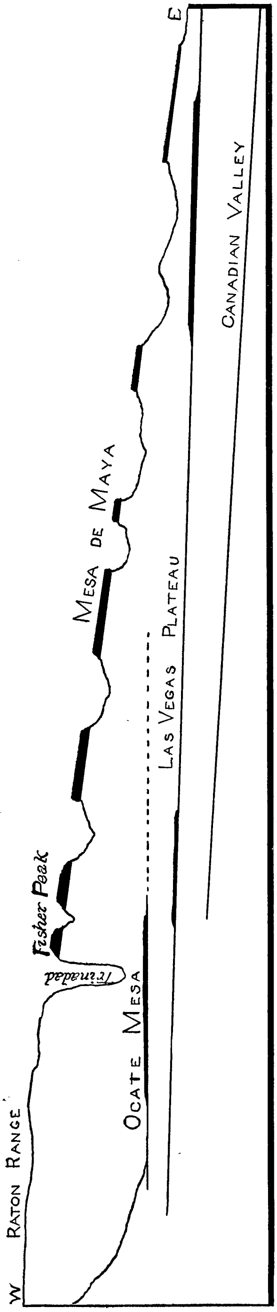

Fig. 1.—Substructure of the Mesa de Maya Plateau; New Mexico.

The most remarkable of these elevated plains is the Mesa de Maya, in northeastern New Mexico. Its extension is the flat crest of the Raton Range. The greater part of the mesa is formed by a thick basalt plate, 500 feet in thickness, resting on the beveled edges of soft Laramie shales and sandstones. This mesa is gently inclined to the eastward and extends from the Rocky Mountains a distance of more than one hundred miles to beyond the Texas line. (See fig. 1). It is 3,500 feet above the next extensive plains-level below, known as the Ocate mesa, which in turn is 500 feet above the general plains-surface of the region, or the Las Vegas plateau. It appears that the Mesa de Maya represents practically a Tertiary peneplain which existed at the time of the general elevation of the region. At the town of Raton its surface is now 9,000 feet above tidewater. Were it not for the great lava-field the remnants of which constitute this plateau-plain there would today remain no undoubted traces of the old peneplain in this part of the country.[1]

That the Mesa de Maya is the remnant of what is essentially a peneplanation-level which, perhaps, once extended over much, if not most, of the present desert region around the southern end of the Rocky cordillera, is strongly supported by a number of facts: (1) The foundation strata, both hard and soft, which alternate frequently, are evenly beveled, indicating that the country at the time of planation must have been only slightly above the sea-level. (2) The principal orogenic deformation and faulting appears to have taken place in early or mid-Tertiary times, and prior to the period of the general planning-off of the country, as represented by the Mesa de Maya level. (3) The numerous mountain ranges of New Mexico, outside of the Rockies, are subequal in height, a fact, when taking into account the period of the principal deformation and faulting, the general alternation of hard and soft belts of rock, and the extent of the subsequent denudation, showing that the present cycle of erosion must have started with the country already more or less of a plain. (4) The present bilateral symmetry of most of the desert ranges, even in the cases of the so-called tilled block-mountains, as the Jemez, Sandia, Franklin, Magdalena, and Caballos ranges, for examples, is suggestive of long-continued attack by the elements upon the hard mountain rock. In each of the mountains mentioned the major fault-line, if it really exists, is as far from the crest of the mountain-ridge as is the foot of the backslope. (5) Plateau plains that lie high above the present general plains-surface, but still far below the Mesa de Maya level, are beveled rock-surfaces, protected usually by lava flows. (6) With all of the present ranges of the so-called block-type bordered on either side by soft beds of great thickness, and the very resistant mountain strata, in monoclinal attitude, once extending such relatively long distances beyond the present mountain crests, it does not seem likely that general lowering of the surface of the country could have gone on so evenly without something of a plains-surface to begin with. (7) The postulation of a general mountainous surface at the commencement of the present geographic cycle as represented by the Mesa de Maya planation surface finds many incongruities which need not be dwelled upon at this time.

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[1] *Proc. Iowa Acad. Sci.*, XV, p. 221, 1908.

How utterly inadequate is any purely tectonic explanation of the larger relief features of the Western desert region, as they today exist, becomes readily apparent so soon as the real nature and the physiographic significance of certain of these characteristics are taken into account. In the consideration of erosional effects in the desert there are some important pecularities which are commonly overlooked.

The principles of water-action in the normal humid lands are applied with the only reservation that there is somewhat less water involved. No distinction is made between the efficiency of water-action on the plain and in the mountain. On the plains, with the exception of the local and sporadic flood-sheet, the general effect of water as a corrading agent is practically *nil*. A very large part of what rainfall occurs on the plains sinks at once into the ground. On the mountains where the general erosion effects have been chiefly observed the results are not so very unlike what they are in the humid regions generally.

By all those who, with the idea of genesis in mind, have recently traversed the region, it is conceded that erosion has had much to do with giving to the desert country its present topographic expression. That the erosion is not chiefly water-erosion but mainly eolian in character is an aspect of the subject which has received but scant attention. The potency of wind-scour as an erosive agent under conditions of dry climate is amply shown in many ways, and to an extent heretofore unsuspected. Its grander effects as compared with those of water corrasion are quite distinctive. Among them none is more characteristic than the beveled rock-floor which the intermont plains of the arid region present, as fully described in detail in another place.[1] Its real significance as indicating that these plains are areas of marked degradation instead of aggredation, as commonly supposed, is here especially pointed out. The vastness and evenness of the intermont plains have no known counterpart among the plains of the humid regions. Desert plains are smoother than peneplains possibly can be, as Passarge has stated. The singular isolation of the desert ranges, for they are usually completely encompassed by plains as by the sea, the entire absence of foothills, the plains-character of the rock-floor itself,[2] the representation of former plains-levels by the plateau-plains, the remarkable thinness of the surface mantle of débris, the total absence of distinct water-ways on the plains,[3] the notable independence of, and marked differences in, level of contiguous plains, and the general tectonic characters,[4] are inexplicable by any method of water-sculpturing. They are all readily accounted for, however, through eolian activities under conditions of an arid climate.

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[1] *Am. Jour. Sci.* (4), XV, p. 207, 1903; also *Bull. Geol. Soc. America*, XIX, p. 86, 1908.

[2] *Eng. and Min. Jour.*, LXVIII, p. 670, 1904.

[3] *American Geologist*, XXXIV, p. 160, 1904.

[4] *U. S. Geol. Sur.*, Water Sup. Pap. No. 123, 1905.

The close tectonic pattern of the American desert region has done much to obscure the real significance of its most striking features. In South Africa, where the great elevated plateau of the dry region has been long relatively free from orogenic movement, there are the same isolated mountains, the same vast and even intermont plains, and the same streamless country. In that region the vigor of wind-scour action and the impotency of water corrasion is amply attested by the recent observations of Passarge,[1] and others. In the Great Basin the wind as a factor in general erosion appears not less effective. It seems probable that we must now regard wind-scour not only the most important erosive agent under conditions of aridity but more potent than all other agencies combined. Moreover, in the production of the present desert mountains its influence doubtless very far surpasses that of any recent deformation or dislocation.

From a view-point of true desert conditions all late observations in the arid country of southwestern United States go to show: (1) That there existed at the beginning of the present geographic cycle a broad peneplain at a level of about 4,000 feet above the present plains-surface; (2) that the major faulting and gentle folding of the region took place chiefly before the beginning of the present cycle; (3) that water-action is unimportant; (4) that wind-scour is very potent; (5) that the belts of hard and soft strata produced by the deformation in former cyles allowed the winds to erode the latter much more rapidly than the former, producing the present plains, and leaving many of the former as monadnock ranges; and (6) that while differential movements of the rock-masses have in all likelihood taken place recently and locally their direct effects compared with those of eolian erosion have been relatively unimportant in the formation of the present orographic expression of the desert country; and (7) that, all things considered, the comparative values of deflation and corrasion in the arid regions may be expressed by the estimate that the volume of rock-waste brought down by the waters from the mountains in a year may be removed by the winds in a single day.

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[1] *Zeitsch. d. deutschen geol. Gesellschaft*, LVI Bd., Protokol, pp. 193–209, 1904.